

U.S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, Secretary
NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

SECOND EDITION

COMMERCIAL STANDARD CS21-34

[Issued August 18, 1934]

Effective Date, September 1, 1934



A RECORDED STANDARD OF THE INDUSTRY

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1934

PROMULGATION STATEMENT

On December 19, 1929, a joint conference of representative manufacturers, distributors, and users of laboratory glassware adopted a commercial standard for interchangeable ground-glass joints which was subsequently accepted by the industry and promulgated as Commercial Standard CS21-30. Following the success of this standard, the standing committee recommended its extension to include interchangeable ground-glass stopcocks and stoppers, and a suitable revision has been accepted and approved by the industry as shown herein for promulgation by the United States Department of Commerce through the National Bureau of Standards.

The standard is effective for new production beginning September 1, 1934.

Promulgation recommended.

I. J. Fairchild,
Chief, Division of Trade Standards.

Promulgated.

Lyman J. Briggs,
Director, National Bureau of Standards.

Promulgation approved.

Daniel C. Roper,
Secretary of Commerce.

INTERCHANGEABLE GROUND-GLASS JOINTS, STOPCOCKS, AND STOPPERS

(Second Edition)

COMMERCIAL STANDARD CS21-34

PURPOSE

1. The purpose of this commercial standard is to provide standard dimensional requirements for obtaining, within practical limits, interchangeability in ground-glass joints, stopcocks, and stoppers for ordinary laboratory and industrial work. It covers dimensional interchangeability only and does not involve physical or chemical characteristics of glass.

SCOPE

2. This standard covers (1) interchangeable ground-glass joints from 3 mm to 65 mm diameters, for laboratory and industrial glassware; (2) interchangeable straight-bore, ground-glass stopcocks from 1 mm to 10 mm bore; (3) interchangeable ground-glass stoppers from 8 mm to 35 mm diameters for volumetric flasks, stoppered Erlenmeyer flasks, stoppered cylinders, separatory funnels, and iodine determination flasks; and (4) interchangeable ground-glass stoppers from 12.5 mm to 40.3 mm diameters for reagent bottles.

GENERAL REQUIREMENTS

3. *Taper.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall have a taper of $1 \text{ mm} \pm 0.006 \text{ mm}$ per centimeter of length on diameter (1 to 10).

4. *Master gages.*—All commercial standard interchangeable ground-glass joints, stopcocks, and stoppers shall be made from working tools that have been checked with standard gages certified by the National Bureau of Standards. A complete set of standard master gages is maintained at the above Bureau for reference.

5. *Master gage material and taper.*—All master gages shall be made of tool steel, hardened and ground. Taper shall be $1 \text{ mm} \pm 0.0006 \text{ mm}$ per centimeter of length on diameter.

DETAIL REQUIREMENTS

A. INTERCHANGEABLE GROUND-GLASS JOINTS

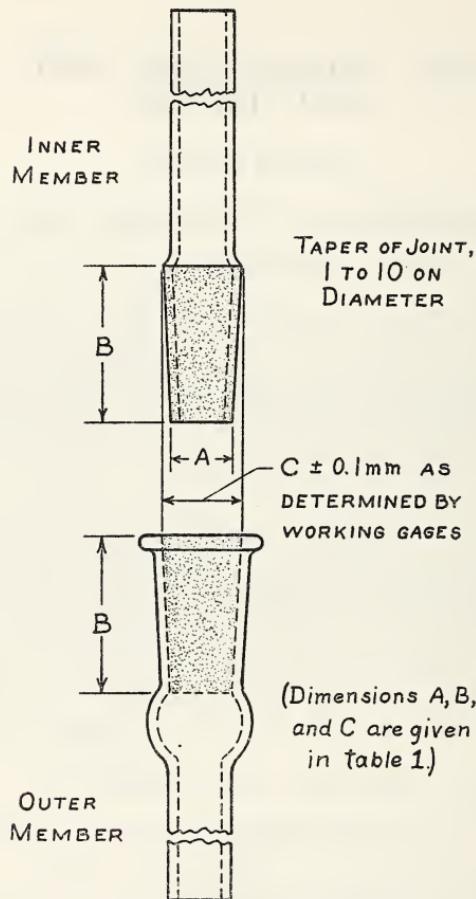


FIGURE 1.—Interchangeable ground-glass joint.

TABLE 1. Standard dimensions for interchangeable ground-glass joints

Standard joint number	Approximate diameter at small end	Approximate length of ground zone	Computed diameter at large end of ground zone (gaging point)
	A	B	C
3.....	3	20	5
5.....	5	25	7.5
7.....	7	30	10
9.....	9	30	12
11.....	11	35	14.5
15.....	15	38	18.8
20.....	20	40	24
25.....	25	42	29.2
30.....	30	45	34.5
40.....	40	50	45
60.....	50	50	55
65.....	65	60	71

NOTE.—Total length of assembled joints shall be approximately 30.5 centimeters (12 inches).

6. *Tube diameter.*—The outside diameter of the tube shall correspond approximately to the outside diameter of the small end of the inner member of the ground joint, dimension A, table 1.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS JOINTS

7. *Plug gage.*—The length of the taper portion of plug gage shall be the approximate length of the ground zone as given in table 1 plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ± 0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

8. *Ring gage.*—Length of ring shall equal approximate length of ground zone as given in table 1 within ± 0.1 mm. Outside diameter of ring shall be approximately twice the diameter at small end of ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

9. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ± 0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and taper shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

10. *Fit of product in working gages.*—The product (both inner and outer members) shall fit in the corresponding working gages within ± 1.0 mm along the axis from the gaging point.

B. INTERCHANGEABLE STRAIGHT BORE GROUND-GLASS STOPCOCKS

11. Interchangeable ground glass stopcocks are not intended for vacuum apparatus or for use with light liquids. When it becomes necessary to replace a plug of an interchangeable stopcock which, by constant abrasion, has become worn so that the shell is enlarged while the plug is diminished in size or otherwise physically or chemically acted upon, then interchangeable stopcock plugs cannot be expected to fit properly in the shell.

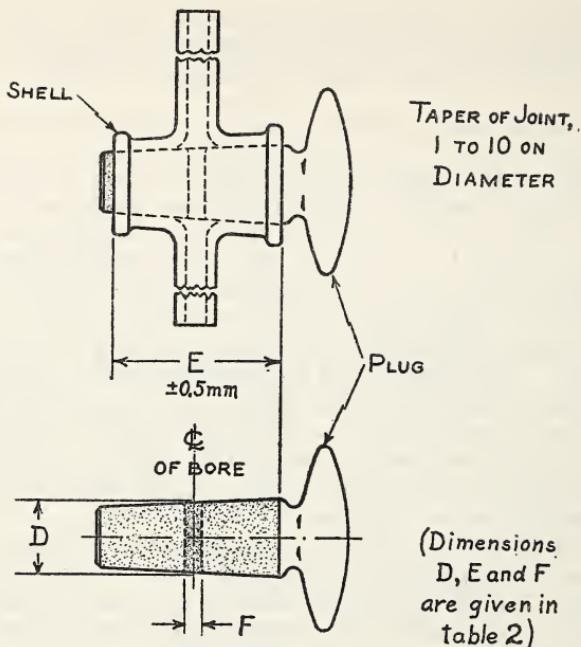


FIGURE 2.—Interchangeable ground-glass stopcock.

TABLE 2.—Standard dimensions for interchangeable straight bore ground-glass stopcocks

Standard stopcock number	Diameter of plug at center line of bore mm	Length of shell ± 0.5 mm	Diameter of bore hole in plug mm	
			D	F
1	12	30		1
1½	12	30		1½
2	12	30		2
3	17	40		3
4	17	40		4
5	20	44		5
6	20	44		6
8	25	52		8
0	35	56		10

12. *Shell*.—The length of shell (product) shall be as given in table 2, plus or minus 0.5 mm.

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS STOPCOCKS

13. *Plug gage*.—The length of taper portion of the master plug gage shall be the length of the shell as given in table 2 plus not less than 12 mm nor more than 14 mm. Plug shall have a circumferential reference line (gaging point) approximately 0.1 mm (0.075 to 0.150 mm) wide located on new gages at a point one-half the length of the shell plus 10 to 11.5

mm from the large end of the taper portion. The diameter at center of reference line (gaging point) shall equal diameter of plug at center line of bore, table 2, within ± 0.003 mm. Plug shall have two short axial lines 180° ($\pm 0.5^\circ$) apart intersecting reference line (gaging point) for checking location of bore hole. Plug gage shall also have two circumferential reference lines near the large end, located at points ($\frac{1}{2} E - 0.5$ mm) and ($\frac{1}{2} E + 0.5$ mm), respectively, from the gaging point. The tolerance on location of these lines shall be plus or minus 0.05 mm. The small and large ends of the taper portion of the gage shall be ground perpendicular to the axis, and each plug gage shall be provided with a suitable handle.

14. *Ring gage.*—The length of the master ring gage shall equal the length of the shell, table 2, plus 0.2 mm, minus 0.0 mm. Ring gage shall have a central milled recess or window. Width of recess measured parallel with the axis shall be approximately one-fourth the length of the shell, and the width of the opening at the inner surface of ring, measured perpendicular to axis, shall not exceed one-fourth the length of the shell. Reference line in recess shall be approximately 0.1 mm (0.75 to 0.150 mm) wide and placed midway between ends of ring gage within ± 0.1 mm on new gages.

15. The outside diameter of rings shall be approximately twice the diameter at center line of bore, table 2, but not less than 25 mm. The ends of the ring gage shall be ground perpendicular to the axis.

16. *Fit of mating gages.*—When a master ring is fitted hand tight on its mating plug, the middle of the reference lines of each member shall not be apart more than 0.15 mm. The finish of the ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with the surface of the plug covered with a light coating of prussian blue in oil. Full contact shall be shown at the reference line (gaging point) under these conditions.

17. *Fit of product in working gages.*—The product (inner member) shall fit in the ring gage so that the bore of the plug shall center on the reference line of the ring gage as near as can be judged by the eye. The shell shall fit on the plug gage so that reference line (gaging point) is $\frac{1}{2} E \pm 0.5$ mm from the large end of the shell. At the center line of bore, the grinding of both plug and shell shall show full contact with the respective gages, and shall be free from any striations. The small end of ground zone of stopcock plug shall extend beyond end of ring gage not less than 2 mm.

C. INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

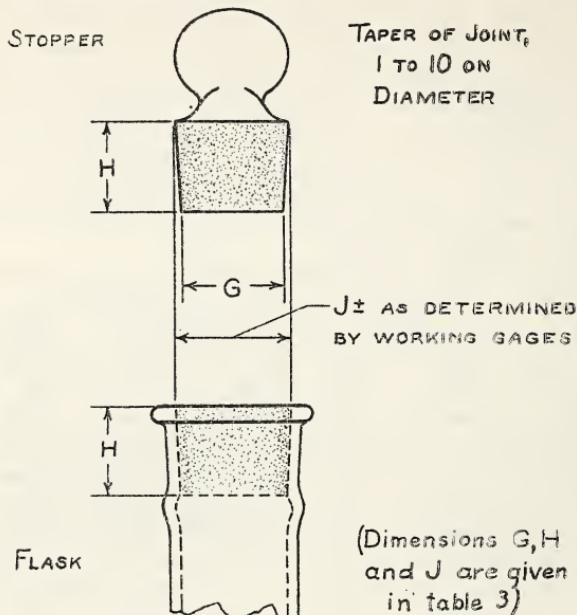


FIGURE 3.—Interchangeable ground-glass flask stopper.

TABLE 3.—Standard dimensions for interchangeable ground-glass flask stoppers

Standard flask stopper number	Approximate diameter at small end mm	Length of ground zone mm	Computed diameter at large end of ground zone (gaging point) mm	Standard flask stopper number	Approximate diameter at small end mm	Length of ground zone mm	Computed diameter at large end of ground zone (gaging point) mm
G	H	J	G	H	J	G	J
8.....	8	14±1	9.4	20.....	20	20.5±1.5	22.06
12.....	12	14±1	13.4	25.....	25	21.5±1.5	27.15
15.....	15	15±1	16.5	30.....	30	21.5±1.5	32.15
18.....	18	17±1	19.7	35.....	35	30 ±2	38.0

MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS FLASK STOPPERS

18. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 3 plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ± 0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

19. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 3 within ± 0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

20. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ± 0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

21. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ± 0.5 mm along the axis for stoppers nos. 8 to 18, inclusive; and within ± 1.0 mm along the axis for stoppers nos. 20 to 35, inclusive.

22. Plug gage shall enter flask so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of flask for stoppers nos. 8 to 18, inclusive; and at least 1.0 mm and not over 3.0 mm for stoppers nos. 20 to 35, inclusive.

D. INTERCHANGEABLE GROUND-GLASS REAGENT BOTTLE STOPPERS

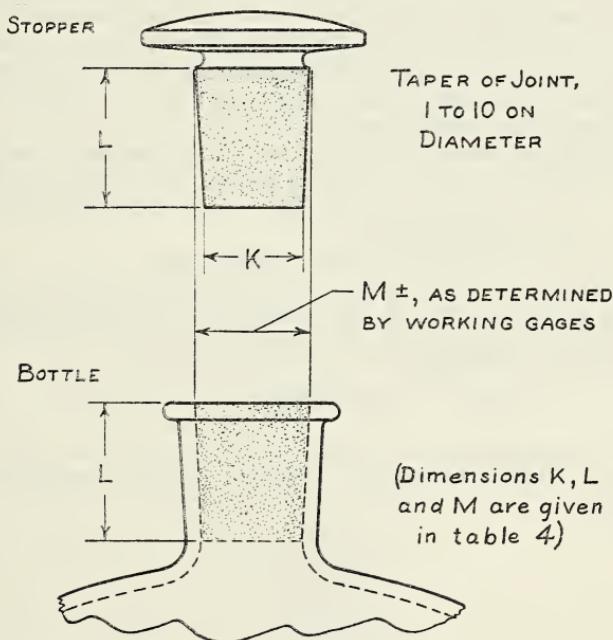


FIGURE 4.—Interchangeable ground-glass reagent bottle stopper.

TABLE 4.—Standard dimensions for interchangeable ground-glass reagent bottle stoppers

Standard bottle stopper number	Approximate diameter at small end	Length of ground zone	Computed diameter at large end (gaging point)	Standard bottle stopper number	Approximate diameter at small end	Length of ground zone	Computed diameter at large end (gaging point)
	K	L	M		K	L	M
12-----	mm 12.5	mm 20±1.5	mm 14.5	25-----	mm 25.5	mm 35±2	mm 29.0
16-----	16.6	22±1.5	18.8	30-----	30.5	40±2	34.5
21-----	21	30±2	24.0	40-----	40.8	47±2	45.0

**MASTER GAGES FOR INTERCHANGEABLE GROUND-GLASS REAGENT
BOTTLE STOPPERS**

23. *Plug gage.*—The length of the taper portion of plug gage shall be the maximum length of the ground zone as given in table 4, plus not less than 12 mm nor more than 14 mm. New gages shall have a diameter at a point 10 mm from the large end of ground portion corresponding to the computed diameter at the large end of ground zone ± 0.005 mm. This point shall be known as the gaging point. Small end of gage and shoulder at large end shall be ground perpendicular to axis. Plug gage shall be provided with a suitable handle.

24. *Ring gage.*—Length of ring shall equal maximum length of ground zone as given in table 4 within ± 0.1 mm. Outside diameter of ring shall be approximately twice the diameter at the small end of the ground zone but not less than 25 mm. Both ends of rings shall be ground perpendicular to the axis.

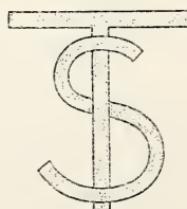
25. *Fit of mating gages.*—When ring is fitted hand-tight on its mating plug, large end of ring shall come within ± 0.15 mm of the gaging point on plug. Finish of ground surfaces on both plug and ring shall be such, and tapers shall match sufficiently, that 75 percent of the ground surface of the ring shall show contact with its mating plug when wrung together with surface of plug covered with a light coating of prussian blue in oil.

26. *Fit of product in working gages.*—The large end of stopper shall come flush with large end of ring gage within ± 0.5 mm along the axis for stoppers nos. 12 and 16 and within ± 1.0 mm along the axis for stoppers nos. 21 to 40, inclusive.

27. Plug gage shall enter bottle so that gaging point on plug shall be at least 0.5 mm and not over 1.5 mm above extreme top surface of bottle for stoppers nos. 12 and 16; and at least 1.0 mm and not over 3.0 mm for stoppers nos. 21 to 40, inclusive.

MARKING

28. Interchangeable ground-glass joints, stopcocks, and stoppers conforming to this commercial standard shall be marked on both members thus,



indicating standard taper, followed by the size number, and a designating trade mark of manufacturer or distributor.

EFFECTIVE DATE

29. The effective date for new production is 6 months after formal acceptance by the industry. Formal acceptance was announced March 1, 1934, and the effective date for new production was accordingly set at September 1, 1934.

HISTORY OF PROJECT

30. Pursuant to a request from manufacturers and distributors of laboratory glassware, a general conference of manufacturers, distributors, and users of interchangeable ground-glass joints was held on December 17, 1929, at the National Bureau of Standards, Washington, D.C., to consider the establishment of commercial standard tapers and diameters on the basis of a preliminary draft submitted by a committee of manufacturers and dealers. The conference adopted the proposed standard unanimously, after making certain minor adjustments, and recommended it for acceptance by the industry. After acceptance had been formally given, the standard was promulgated and issued in printed form as Commercial Standard CS21-30 which became effective August 1, 1930.

FIRST REVISION

31. The standing committee, as a result of conferences on May 25 and July 20, 1933, recommended the extension of the commercial standard to include 3, 9, and 65 mm sizes of interchangeable ground-glass joints; 5 sizes of interchangeable straight-bore, ground-glass stopcocks; 8 sizes of interchangeable ground-glass flask stoppers; and 6 sizes of interchangeable ground-glass reagent bottle stoppers. The proposed revision was circulated to the industry on January 5, 1934, for written acceptance, with the result that the revised standard was accepted and authorized by the industry for publication as Commercial Standard CS21-34.

STANDING COMMITTEE

32. The following constitutes the present membership of the standing committee appointed originally by the general conference of December 17, 1929, to represent the various phases of the industry and give final consideration to comments and suggestions for improvement of the commercial standard:

J. EDWARD PATTERSON (chairman), Arthur H. Thomas Co.
WALTER R. EIMER, Eimer & Amend.
FREDERICK KRAISL, Corning Glass Works.
WILLIAM GEYER, Scientific Glass Apparatus Co.
HERMAN K. KIMBLE, Kimble Glass Co.
LEONARDO TESTA, Fixed Nitrogen Laboratory.
EDWARD H. COX, Swarthmore College.
W. D. COLLINS, American Chemical Society.
D. R. MILLER, National Bureau of Standards.

APPENDIX

The success of the original Commercial Standard CS21-30, on interchangeable ground-glass joints, led the standing committee to recommend an extension of the principle of interchangeability to other items. From the point of view of the National Bureau of Standards, the revised standard should be considered as more or less on trial and subject to such future changes as may be warranted by composite experience.

ACCEPTANCE OF COMMERCIAL STANDARD

This sheet properly filled in, signed, and returned will provide for the recording of your organization as an acceptor of this commercial standard.

Date _____

**DIVISION OF TRADE STANDARDS,
NATIONAL BUREAU OF STANDARDS,
Washington, D.C.**

GENTLEMEN: Having considered the statements on the reverse side of this sheet, we accept the Commercial Standard CS21-34 as our standard of practice in the
 {production¹} of interchangeable ground-glass joints, stop-
 {distribution¹} cocks, and stoppers.
 use¹

We will assist in securing its general recognition and use, and will cooperate with the standing committee to effect revisions of the standard when necessary.

Signature _____

(Kindly typewrite or print the following lines)

Title _____

Company _____

Street address _____

City and State _____

¹ Please designate which group you represent by drawing lines through the other two. In the case of related interests, trade papers, colleges, etc., desiring to record their general approval the words "In principle" should be added after the signature.

TO THE ACCEPTOR

The following points are given in answer to the usual questions arising in connection with the acceptance form:

1. Commercial standards are commodity specifications voluntarily established by mutual consent of the industry. They present a common basis of understanding between the producer, distributor, and consumer and should not be confused with any plan of governmental regulation or control. The United States Department of Commerce has no regulatory power in the enforcement of their provisions, but since they represent the will of the industry as a whole, their provisions through usage soon become established as trade customs.

2. *The acceptor's responsibility.*—The purpose of commercial standards is to establish for specific commodities, nationally recognized grades or consumer criteria, and the benefits therefrom will be measurable in direct proportion to their general recognition and actual use. Instances will occur when it may be necessary to deviate from the standard and the signing of an acceptance does not preclude such departures; however, such signature indicates an intention to follow the commercial standard where practicable in the production, distribution, or consumption of the article in question.

3. *The Department's responsibility.*—The function performed by the United States Department of Commerce in the establishment of a commercial standard is fourfold: first, to act as an unbiased coordinator to bring all branches of the industry together for the mutually satisfactory adjustment of trade standards; second, to supply such assistance and advice as past experience with similar programs may suggest; third, to canvass and record the extent of acceptance and adherence to the standard; and fourth, to add all possible prestige to the enterprise by publication and promulgation when accepted by the industry.

When the standard has been endorsed by companies representing a satisfactory majority of production, the success of the project is announced. If, however, in the opinion of the standing committee of the industry or the United States Department of Commerce, the support of any standard is inadequate, the right is reserved to withhold promulgation and publication.

ACCEPTORS

Individuals and organizations listed below have indicated in writing, acceptance of this specification as their standard of practice, but such endorsement does not signify that they may not find it necessary to deviate from the standard, or that they guarantee all their products to conform to the requirements of this standard.

ASSOCIATIONS

American Hospital Association, Chicago, Ill.

Portland Cement Association, Chicago, Ill.

FIRMS

University of Akron, Department of Chemistry, Akron, Ohio.

Alabama Polytechnic Institute, School of Chemistry, and Pharmacy, Auburn, Ala.

Alaska Agriculture College and School of Mines, Chemistry Department, College, Alaska.

Alfred University, Alfred, N.Y. (in principle).

Almo Manufacturing Co., Newark, N.J.

Analytical Laboratories, Jersey City, N.J.

A. B. Andrews, State Assayer, Lewiston, Maine.

University of Arizona, Tucson, Ariz. (in principle).

Dr. Henry Arnstein, Philadelphia, Pa.

Baker University, Baldwin City, Kans. (in principle).

Barrett Co., The, Edgewater, N.J.

Barrow-Agee Laboratories, Inc., Memphis, Tenn.

Battle Laboratory, Inc., The, Montgomery, Ala.

Baylor College, Chemistry Department, Belton, Tex. (in principle).

Baylor University, Chemistry Department, Waco, Tex.

Bell & Beltz, Inc., Philadelphia, Pa.

J. & H. Berge, New York, N.Y.

Black & Deason, Salt Lake City, Utah.

Block Laboratories, Chicago, Ill.

Bradley Polytechnic Institute, Chemistry Department, Peoria, Ill.

Braun Corporation, Los Angeles, Calif.

Brewer & Gardner, Philadelphia, Pa.

Bridgeport Testing Laboratory, Bridgeport, Conn.

Brown & Sharpe Manufacturing Co., Providence, R.I. (in principle).

Bucknell University, Chemical Department, Lewisburg, Pa.

Buffalo Apparatus Corporation, Buffalo, N.Y.

Burrel Technical Supply Co., Pittsburgh, Pa.

Butler University, Chemical Laboratory, Indianapolis, Ind. (in principle).

California Institute of Technology, Chemistry Department, Pasadena, Calif.

Calkins Co., Inc., The, Los Angeles, Calif.

Canton Glass Co., The, Marion, Ind.

Carnegie Institute of Technology, Chemistry Department, Pittsburgh, Pa.

Catholic University of America, The, School of Engineering, Washington, D.C. (in principle).

Central Scientific Co., Chicago, Ill.

Chicago Apparatus Co., Chicago, Ill.

Clarkson College of Technology, Chemical Engineering, Potsdam, N.Y. (in principle).

Colby College, Chemistry Department, Waterville, Maine (in principle).

College of the Pacific, Chemistry Department, Stockton, Calif.

Colorado Agricultural College, Department of Chemistry, Fort Collins, Colo.

Colorado College, Chemistry Department, Colorado Springs, Colo. (in principle).

Colorado School of Mines, Department of Chemistry, Golden Colo. (in principle).

Consolidated Gas Co. of New York, New York, N.Y.

E. L. Conwell & Co., Philadelphia, Pa.

Cornell University, Department of Chemistry, Ithaca, N.Y.

Corning Glass Works, Corning, N.Y.

Crismon & Nichols, Salt Lake City, Utah.

W. H. Curtin & Co., Inc., Houston, Tex.

A. Daigger & Co., Chicago, Ill.

C. W. Danforth Co., The, Youngstown, Ohio.

Dartmouth College, Department of Chemistry, Hanover, N.H. (in principle).

University of Dayton, Department of Chemistry, Dayton, Ohio (in principle).

Denison University, Chemistry Department, Granville, Ohio (in principle).

Detroit Testing Laboratory, The, Detroit, Mich.

University of Detroit, Chemistry Department, Detroit, Mich.

Dodge Steel Casting Co., Philadelphia, Pa.

Drexel Institute, Philadelphia, Pa.

Drury College, Chemistry Department, Springfield, Mo.

Dumas Laboratory, The, Atlanta, Ga.

El Paso Testing Laboratories, El Paso, Tex.

Erie Laboratory, The, Erie, Pa.

Falkenburg & Co., Seattle, Wash.

C. M. Fassett Co., Inc., The, Spokane, Wash.

Fisher Scientific Co., Pittsburgh, Pa.

Forest City Testing Laboratory, The, Cleveland, Ohio.

Froehling & Robertson, Inc., Richmond, Va.

Hamline University, Chemistry Department, St. Paul, Minn.

Geijsbeek Engineering Co., Seattle, Wash.

George Washington University, Department of Chemistry, Washington, D.C.

University of Georgia, Department of Chemistry, Athens, Ga. (in principle).

Gettysburg College, Chemistry Department, Gettysburg, Pa. (in principle).

W. J. Gilmore Drug Co., Laboratory Apparatus Department, Pittsburgh, Pa.

Glascote Co., Inc., The, Euclid, Ohio.

Goodman-Kleiner Co., Inc., New York, N.Y.

Otto R. Greiner Co., Newark, N.J.

University of Hawaii, Chemistry Department, Honolulu, Hawaii.

H-B Instrument Co., Inc., Philadelphia, Pa.

Gerald K. Heller Co., Baltimore, Md.

Hercules Experiment Station, Wilmington, Del.

James H. Herron Co., The, Cleveland, Ohio.

Hochstadter Laboratories, Inc., New York, N.Y.

Howard College, Chemistry Department, Birmingham, Ala. (in principle).

Howard Payne College, Chemistry Department, Brownwood, Tex.

Howe & French, Inc., Boston, Mass.

Humboldt Manufacturing Co., Chicago, Ill.

University of Idaho, Chemistry Department, Moscow, Idaho (in principle).

Illinois Wesleyan University, Chemistry Department, Bloomington, Ill.

Indiana University, Chemistry Department, Bloomington, Ind.

Indianapolis Water Co., Indianapolis, Ind.

Industrial Research Laboratories, Muskegon, Mich.

Janes & Breckler, Louisville, Ky.

Johns Hopkins University, The, Department of Chemistry, Baltimore, Md.

Wilbur L. Jones, Madison, Wis.

Charles C. Kawin Co., Chicago, Ill.

Kauffman-Lattimer Co., Columbus, Ohio.

University of Kentucky, Department of Chemistry, Lexington, Ky.

Kimble Glass Co., Vineland, N.J.

Lafayette College, Chemistry Department, Easton, Pa.

Law & Co., Inc., Wilmington, N.C.

LaWall & Harrisson, Philadelphia, Pa.

Lawrence College, Appleton, Wis.

E. Leitz, Inc., New York, N.Y.

Lewis Institute, Chemistry Department, Chicago, Ill. (in principle).

Arthur D. Little, Inc., Cambridge, Mass.

University of Louisville, Department of Chemistry, Louisville, Ky.

Lovelock Assay Office, Lovelock, Nev.

Lowell Textile Institute, Chemistry and Textile Coloring, Lowell, Mass.

Luertzing Glass Instrument Co., Vineland, N.J.

Macalaster Bicknell Co., Cambridge, Mass.

E. Machlett & Son, New York, N.Y.

University of Maine, Chemistry and Chemical Engineering, Orono, Maine (in principle).

University of Maryland, Department of Physical Chemistry, College Park, Md. (in principle).

Massachusetts Institute of Technology, Research Laboratory of Organic Chemistry, Cambridge, Mass.

Frederick J. Maywald, Carlstadt, N.J.

Michigan College of Mining and Technology, Chemistry Department, Houghton, Mich. (in principle).

Michigan State College, East Lansing, Mich.

Middlebury College, Chemistry Department, Middlebury, Vt.

Geo. M. Miles, Boston, Mass.

Mills College, Chemistry Department, Mills College, Calif. (in principle).

Milwaukee Glass Works, Inc., Milwaukee, Wis.

Mine and Smelter Supply Co., The, Laboratory and Chemical Department, Denver, Colo.

Miner Laboratories, The, Chicago, Ill.

University of Minnesota, School of Chemistry, Minneapolis, Minn.

Minnesota Testing Laboratories, Inc., Duluth, Minn.

Monmouth College, Department of Chemistry, Monmouth, Ill. (in principle).

Montana School of Mines, Chemistry Department, Butte, Mont.

Mount Vernon Car Manufacturing Co., Mount Vernon, Ill.

Muskingum College, Department of Chemistry, New Concord, Ohio.

National Testing Laboratories, Inc., Rochester, N.Y.

University of Nebraska, Department of Chemistry, Lincoln, Nebr. (in principle).

L. G. Nester Co., Inc., Millville, N.J.

University of Nevada, Department of Chemistry, Reno, Nev. (in principle).

University of New Hampshire, Chemistry Department, Durham, N.H. (in principle).

New Jersey Laboratory Supply Co., Newark, N.J.

New Mexico College of A. & M. A., Chemistry Department, State College, N. Mex.

New Mexico School of Mines, Chemistry Department, Socorro, N. Mex.

New Mexico State Highway Department, Las Cruces, N. Mex.

College of the City of New York, New York, N.Y.

New York Testing Laboratories, New York, N.Y.

University of North Carolina, Department of Chemistry, Chapel Hill, N.C. (in principle).

North Dakota Agricultural College, School of Chemistry, Fargo, N.Dak.

Norwich University, Department of Chemistry, Northfield, Vt.

University of Notre Dame, Departments of Chemistry and Chemical Engineering, Notre Dame, Ind.

Occidental College, Chemistry Department, Los Angeles, Calif.

Ohio Northern University, Department of Chemistry, Ada, Ohio.

Ohio State University, Department of Chemical Engineering, Columbus, Ohio (in principle).

Ohio University, Chemistry Department, Athens, Ohio.

Ohio Wesleyan University, Chemistry Department, Delaware, Ohio.

Oklahoma A. & M. College, Stillwater, Okla.

Oklahoma College for Women, Chemistry Department, Chickasha, Okla. (in principle).

Oklahoma Testing Laboratories, Oklahoma City, Okla.

Ottawa University, Ottawa, Kans. (in principle).

Pacific Coast Testing Laboratory, Seattle, Wash.

Patzig Laboratories, Des Moines, Iowa.

Pease Laboratories, Inc., Department of Chemistry, New York, N.Y.

A. L. Pellegrin & Son, Tucson, Ariz.

A. L. Pellegrin & Son, Calexico, Calif.

Pennsylvania State College, The Chemical Laboratories, State College, Pa. (in principle).

University of Pennsylvania, Department of Chemistry and Chemical Engineering, Philadelphia, Pa. (in principle).

Perry Testing Laboratory, Detroit, Mich.

Laboratories of Charles L. W. Pettee, Hartford, Conn.

University of the Philippines, Department of Agricultural Chemistry, Laguna, P.I. (in principle).

Phoenix Chemical Laboratory, Inc., Chicago, Ill.

Lucius Pitkin, Inc., New York, N.Y.

Pratt Institute, Department of Chemical Engineering, Brooklyn, N.Y.

Purdue University, Department of Chemistry, Lafayette, Ind. (in principle).

Rascher & Betzold, Chicago, Ill. (in principle).

Refinery Supply Co., The, Tulsa, Okla.

Rensselaer Polytechnic Institute, Department of Chemical Engineering, Troy, N.Y. (in principle).

Rhode Island State College, Chemistry Department, Kingston, R.I. (in principle).

Rice Institute, The, Houston, Tex. (in principle).

Rose Polytechnic Institute, Chemical Engineering and Chemistry, Terre Haute, Ind.

Rutgers University, School of Chemistry, New Brunswick, N.J.

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State Chemical Laboratory of South Dakota, Vermillion, S.Dak.

South Dakota State College, Chemistry Department, Brookings, S.Dak.

South Dakota State School of Mines, Department of Chemical Engineering, Rapid City, S.Dak. (in principle).

Specialty Glass Co., Chicago, Ill.

Standard Glass Apparatus Works, Freeport, Long Island, N.Y.

John B. Stetson University, Chemistry Department, DeLand, Fla.

Herman Strauss Corporation, New York, N.Y.

Swarthmore College, Swarthmore, Pa. (in principle).

Syracuse University, Chemistry Department, Syracuse, N.Y. (in principle).

A. & M. College of Texas, Department of Chemistry and Chemical Engineering, College Station, Tex.

Texas Technological College, Department of Chemistry and Chemical Engineering, Lubbock, Tex. (in principle).

University of Texas, Chemistry Department, Austin, Tex. (in principle).

University of Virginia, Chemistry Department, University, Va. (in principle).

Textor Chemical Laboratories, Cleveland, Ohio.

Arthur H. Thomas Co., Philadelphia, Pa.

Trinity College, Chemistry Department, Hartford, Conn. (in principle).

Trinity University, Physical Science Department, Waxahachie, Tex. (in principle).

Tufts College, Chemistry Department, Tufts College, Mass. (in principle).

Twining Laboratories, The, Fresno, Calif.

Universal Oil Products Co., Research and Development Laboratories, Riverside, Ill.

University of Utah, Chemistry Department, Salt Lake City, Utah.

Van Cleve Laboratories, Inc., Minneapolis, Minn.

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Washington and Lee University, Chemical Department, Lexington, Va. (in principle).

State College of Washington, Department of Chemistry, Pullman, Wash.

Washington University, Chemistry Department, St. Louis, Mo. (in principle).

Watters Laboratories, New York, N.Y.

Wellesley College, Department of Chemistry, Wellesley, Mass. (in principle).

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